

## REPORT DOCUMENTATION PAGE

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14. ABSTRACT The goal of this research is to develop novel polymer nanocomposites with improved shape-flexibility, ease in processing, and high ratio of magnetic permeability ( $\mu_r$ ) to dielectric permittivity ( $\epsilon_r$ ) for smaller physical size, wider bandwidth, and higher power efficiency antenna systems. The research effort consisted of: 1) investigation of the influence of nanoparticle dimension, chemical composition, and orientation within polymer matrices on magneto-dielectric properties, 2) synthesis of polymer compatible, low energy loss nickel zinc iron oxide magnetic nanoparticles with various particle sizes, 3) polymer antenna construction and evaluation of performance.					
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**Grant/Contract Title: BLOCK COPOLYMER MAGNETIC NANOARCHITECTURES  
FOR RF APPLICATIONS**

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**FINAL REPORT**

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The goal of this research is to develop novel polymer nanocomposites with improved shape-flexibility, ease in processing, and high ratio of magnetic permeability ( $\mu_r$ ) to dielectric permittivity ( $\epsilon_r$ ) for smaller physical size, wider bandwidth, and higher power efficiency antenna systems. The research effort consisted of: 1) investigation of the influence of nanoparticle dimension, chemical composition, and orientation within polymer matrices on magneto-dielectric properties, 2) synthesis of polymer compatible, low energy loss nickel zinc iron oxide magnetic nanoparticles with various particle sizes, 3) polymer antenna construction and evaluation of performance.

**Key Accomplishments**

- 1. Understanding nanoparticle magnetic domain wall movement and its effect on polymer composite properties.** Hard ferrite nanoparticles exhibited lower magnetic permeability than soft ferrites due to difficulty in domain wall movement. Magnetic nanoparticles with multi-domains showed lower permeability compared to single domain particles due to domain wall re-arrangement.
- 2. Synthesis of high resistivity soft ferrite nanoparticles for low loss RF polymer composites.** Highly crystalline, surface-modified  $\text{Ni}_x\text{Zn}_{1-x}\text{Fe}_2\text{O}_4$  nanoparticles of various chemical compositions were successfully synthesized. We managed to tailor a specific size (ranging from 5nm to 30nm) and shape (spherical or irregular) of these nanoparticles by a seed-mediated growth method. The permittivity ( $\epsilon_r$ ) and permeability ( $\mu_r$ ) of the polymer composites were optimized for  $\text{Ni}_x\text{Zn}_{1-x}\text{Fe}_2\text{O}_4$  nanoparticle doping. The dielectric loss ( $\tan \delta$ ) of the nanocomposites was less than 0.010.
- 3. Development of a procedure for fabrication and processing of polymer nanoparticle composites.** Polymer composites, applicable to conformal antenna installations, including thin sheets and bulky bars were prepared by a low-cost solution-casting method.
- 4. Understanding the influence of magnetic particle orientation within polymer matrices on the magnetic permeability of the nanocomposite.** Polymer composites with layered nanoparticles showed higher magnetic permeability compared to randomly dispersed nanoparticles. This promising improvement, resulted from the easily-magnetized structure of layered nanoparticles and by the reduction of adverse eddy currents.
- 5. Construction and evaluation of nanocomposite antenna performance.** An inverted F antenna (IFA) was fabricated using polymer nanocomposites. A quality factor of  $Q \approx 50$  at 433 MHz ( $\lambda = 69.28$  cm) and 868 MHz ( $\lambda = 34.56$  cm) was measured.

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